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Bulletin No. 69 - The Golden Vine Field Pea: Its Chemical Composition and Forage Value

John Stewart

EXPERIMENT STATION

OF

THE AGRICULTURAL COLLEGE

OF UTAH.

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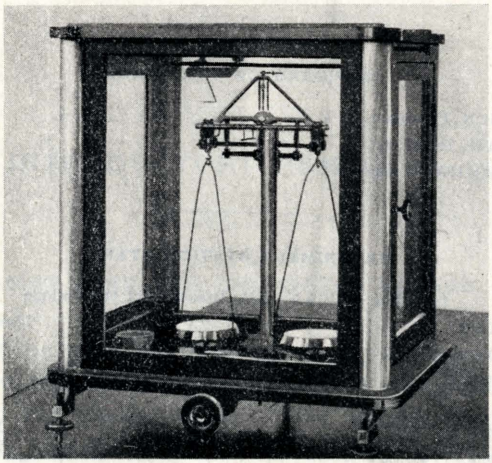

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THE GOLDEN VINE FIELD PEA.

ITS CHEMICAL COMPOSITION AND FORAGE VALUE.

JOHN STEWART.

INTRODUCTORY REMARKS.

THE INCREASING NEED FOR CULTIVATED FORAGE CROPS.

For some time past the Division of Agrostology has been conducting investigations in various parts of the United States with a view to the preservation of our native grasses, the introduction of new varieties, and the improvement of the ranges. The investigation in Texas, where the once fine ranges have been seriously injured or totally destroyed on account of the greed and carelessness of stockmen, is an important one.

In his last report, the Secretary of Agriculture recommends that provisions be made for renting the public lands, suitable for grazing purposes, to stockmen and sheepmen for a number of years. By this means it is thought that the ranges will be preserved and improved; for then each individual who makes use of them will be financially interested in a definite tract for a sufficiently long time to warrant him taking the best care of it.

These movements on the part of the Department of Agriculture are merely effects of the growing demand for more

forage crops. The stockmen and the sheepmen of the future have got to depend more and more upon the cultivation of forage crops for the maintenance of their cattle and sheep, not only during the winter, but also during the summer.

SOME PLANTS USED AS COARSE FODDER IN UTAH.

Quite a number of plants are used, more or less extensively, as coarse fodders in Utah. Salt-grass, bayonet grass and foxtail are some native grasses which are used in alkali districts to a slight extent. Redtop, timothy and lucern are cultivated; and barley, wheat, rye, oats and corn fodder are sometimes cured and used as hay. But, of all these, lucern is the staple forage crop of Utah.

THE OBJECT OF THE STUDY RECORDED HEREIN.

The cowpea in the Southern States and the more hardy varieties of field peas in the North and in Canada have been found to be profitable crops on account of their yield per acre, ease of cultivation, forage value and beneficial effect on the land either when merely grown on it or used as a fertilizer. However valuable a crop lucern is, it goes without saying that the feeder cannot rely entirely upon it. Aside from the injurious effects on the animal of a single food diet, there are the practical problems of cultivation and expediency. In this investigation it was, therefore, intended to determine the chemical composition of the pea vine, the relative proportion of leaves, stalks and pods, and their composition at different stages of growth; also to collect other data showing the forage value of pea vine hay. The collection of accurate data on these points and a comparison with other forage crops, especially lucern, may show it to be expedient and profitable to cultivate this plant more extensively in Utah for feeding purposes.

THE METHOD OF CONDUCTING THE INVESTIGATION.

A plat of peas (Golden Vine) was selected from those on the Station farm for this study. It was seeded April 15, 1899, and watered June 15th, July 6th and 17th.

Weekly, commencing with June 19th and ending July 31st, the percentage of water in the growing plant, the proportion of leaves, stalks and pods (or flowers), and the weight of the

green matter per acre were determined. Samples were also taken weekly and later submitted to the usual food analysis according to the Official method.

For all these determinations, samples were taken from two different parts of the field each week. The percentages of moisture, crude protein, amides and albuminoids are the averages of four determinations; the other percentages are the averages of two determinations.

In the analyses the composition of the leaves, stalks and pods was determined separately. From these results and the proportion of these organs in the plant, the composition of the whole plant was calulated.

COMPOSITION AND YIELD PER ACRE.

THE PROPORTION OF LEAVES, STALKS AND PODS (OR FLOWERS.)

Table I below gives the proportion of leaves, stalks and flowers in the growing plant, and in the plant when dry. The per cent of leaves is a little higher, and of stalks a little lower in the dry than in the green plant. Three-fourths of the green plant consists of leaves when it is young and one-fourth of stalks. At maturity a little more than two-fifths are leaves; a little more than one-fifth, stalks; and a little less than two-fifths, pods. In both the dry and the green plant the variation is similar, but slightly greater in the dry plant. The per cent of leaves decreases from youth to maturity; the per cent of stalks increases until the pods begin to form and then decreases; the per cent of pods, of course, increases as the plant grows older.

A comparison of this table with Table IV, in Bulletin 48 of this Station, reveals the fact that the per cent of leaves and pods is considerably higher in peas than in lucern for like stages of growth, while that of stalks is correspondingly lower. At the cutting period (in early bloom) the pea plant is two-thirds leaves, the lucern plant, two-fifths leaves.

TABLE I.—PER CENT. OF LEAVES, STALKS AND FLOWERS.

	In the Green Plant.			In the Dry Plant.		
Date.	Leaves	Stalks	Flowers	Leaves	Stalks	Flowers and Pods
June 19	73.81	26 19	None	79.06	20.94	None
June 26	73.46	26.54	None	76.60	23.40	None
July 3	68.06	31.94	None	72.76	27.24	None
July 10	62.16	30.86	6.98	66.98	27.83	5.19
July 17	50.77	28.23	21.00	56.67	28.69	14.64
July 24	42.77	19.88	37.35	48.61	19.70	31.69
July 31	41.79	22.65	35.56	40.89	17.02	42.09

THE PERCENTAGE OF WATER IN THE GROWING PLANT.

The pea is a very succulent plant. It contains nearly as high a per cent of water as carrots, mangels, beets and other root crops, and a considerably higher per cent than most grasses and many other plants used as forage. When it is very young, it contains more water than milk does.

A comparison of the per cents given in Table II below with the data given in Bulletin 48 of this Station, shows that at the time to cut for hay (that is, in early or medium bloom) the pea vine contains, on an average, about five per cent more water than lucern does. This statement holds true for all three crops of lucern. This difference will probably be greater in other regions, as the moisture in lucern, determined elsewhere, is about 8 per cent lower than here, while that in cowpeas (a similar plant to the Golden Vine) is about 1 per cent higher elsewhere than in the Golden Vine here.

It would be interesting, from a practical as well as a scientific point of view, to have a good explanation of the fact that different plants contain unlike proportions of water. No explanation has come to my notice. The fact that grasses have a finer structure than lucern, peas and many root crops might indicate that the mere physical capacity were a cause of the different content of water; but that each kind of plant requires for its vital processes a certain proportion different from that of other kinds of plants, is doubtless true.

Table II shows that on July 17th and 24th the per cent of water in the pods and flowers was greater than in the leaves and stalks at that time, and above 80 per cent. The per cent

in the leaves and stalks prior to July 10th was also, with one exception, above 80 per cent. The leaves and stalks ceased to grow on July 10th, and the pods on July 24th. When the lucern ceased to grow in Prof. Widtsoe's experiment, as shown in Bulletin 48, the per cent of moisture in the whole plant was 75, in the leaves 80, stalks 70 and flowers 80 in the first crop; and in the second crop it was 73 in the whole plant, 71.5 in the leaves, 65.5 in the stalks and 78 in the flowers. In these experiments, then, lucern contained a lower per cent of water at the cessation of growth than the peas did.

Lawes and Gilbert in England have made some determinations of the proportion of water, passing through some plants during their growth, to the dry matter formed. King in Wisconsin did some similar work except that his determinations included the water evaporated from the soil supporting the plants. It would be interesting to know the proportion of water which various seeds must contain in order to germinate.

As is shown in Table II, the stalks contain a higher per cent of water than the leaves. This is, of course, to be expected, as the leaves expose a greater surface to evaporating influences and are more remote from the source of the water.

TABLE II.—PER CENT OF WATER IN GROWING PLANT.

Date	Whole Plant.	Leaves.	Stalks.	Flowers.
June 19	88.30	87.47	90 64	.....
" 26	87.56	87.03	89.03	.....
July 3	80.47	79.13	83.33	.....
" 10	82.83	81.50	84.51	87.25
" 17	79.12	76.70	78.77	85.44
" 24	79.36	76.55	79.54	82.48
" 31	70.39	71.02	77.77	64.94

CROP YIELD PER ACRE.

The weight, in pounds, of green material, dry material and water per acre at different stages of growth is given in Table III. On June 19th the plant was about nine inches high.

In the leaves, stalks and whole plant the greatest yield per acre, both of green and dry matter, occurred on July 10th. The largest yield of green material and dry material in the pod

occurred on July 24th. At the time of greatest yield per acre, in early bloom, two-thirds of the whole crop consisted of leaves.

If the plant were cut for hay, it would probably be best to cut in early bloom. At this time the yield of dry matter per acre was 4,997 lbs.—equivalent to $2\frac{3}{4}$ tons of hay, on the assumption that the hay contains 10 per cent of water. Lucern, cut in early bloom, gave an average yield during five years of 5.36 tons per acre at this Station, as shown in Bulletin 61. Up to the present it has been found impracticable to produce two full crops of peas in one season at this Station; but this difficulty could probably be obviated by cutting in early bloom, which, as shown below, appears to be the best time.

In South Dakota*, two varieties of field peas yielded respectively 1,400 and 1,520 pounds of dry hay per acre. In the Gulf States, cowpeas† yield on an average 2 to 3 tons per acre and 4 to 6 tons are not uncommon.

TABLE III.—YIELD PER ACRE.

(a) GREEN MATERIAL

Date.	Total	Leaves.	Stalks.	Flowers.
June 19	8002.	5906.	2096.	.....
" 26	13088.	9614.	3474.	.....
July 3	13225.	9001.	4224.	.....
" 10	29103.	18090.	8982.	2031.
" 17	21129.	10727.	5964.	4437.
" 24	16938.	7245.	3367.	6327.
" 31	8976.	3751.	2033.	3192.

(b) DRY MATERIAL.

Date.	Total	Leaves.	Stalks.	Flowers.
June 19	936.	740.	196.	.....
" 26	1628.	1278.	381.	.....
July 3	2583.	1879.	704.	.....
" 10	4997.	3347.	1391.	259.
" 17	4412.	2500.	1266.	646.
" 24	3496.	1699.	689.	1108.
" 31	2658.	1087.	452.	1119.

* Bulletin 59, So. Dakota Exp. Sta.

† Farmers' Bulletin 89, U. S. Dept. Agr.

TABLE III—YIELD PER ACRE—CONTINUED.

(c) WATER.

Date.	Total	Leaves.	Stalks.	Flowers.
June 19	7066.	5166.	1900.	.....
" 26	11460.	8367.	3093.	.....
July 3	10642.	7122.	3520.	.....
" 10	24106.	14743.	7591.	1772.
" 17	16717.	8227.	4698.	3791.
" 24	13442.	5546.	2678.	5219.
" 31	6318.	2664.	1581.	2073.

RATE OF GROWTH.

An examination of Table IV will show the rate of growth of the crop. The figures represent pounds per acre, the sign + indicating gain and — indicating loss.

The part of the table showing the gain or loss of water, illustrates the effect of irrigation. Between June 26th and July 3rd, the leaves lost over a half ton of water per acre. The crop was watered on July 6th, and in the next four days it took up about 6¾ tons of water per acre. After July 10th the crop continued to lose water rapidly; but between July 17th and 24th the loss was greatly checked on account of the field being watered on July 17th. Notwithstanding the enormous amount of water taken up from July 6th to 10th, the water in the plant was increased only 2.36 per cent.

Up to June 10th the weather was cold, and in April and May there had been frosts. The average temperature rose over 10 degrees for the period from June 10th to 18th. On June 19th, when the first samples were taken, the dry matter on an acre was less than a half ton. During the next week the crop gained about three-quarters as much dry material as it had during its entire previous growth. Although the crop was losing water during the next week, the gain in dry matter was nearly a half ton, and in the next week when the field had been watered, 2,414 lbs. of dry matter were added to the acre crop. Over four-fifths of the entire weight of the crop on July 10th had been produced during the three previous weeks. This plant is certainly a remarkably rapid grower.

Bulletin 48 of this Station shows 789 lbs of dry matter to be the greatest weekly growth of lucern per acre observed in the experiment recorded therein.

Another glance at Table IV will show that, while the leaves increased rapidly in dry weight until July 10th, the ratio of their growth to that of the stalks was much greater prior to June 26th than thereafter. After July 10th the growth occurred only in the pods and flowers. In other words, the energies of the plant are first directed toward the development of the organs by which it is supported, then to the strengthening of itself, than to the perpetuation of the species.

After July 10th both leaves and stalks lost weight. The loss in the former can be accounted for by the falling of the leaves. It is difficult to account for the loss in the stalks; but it may be partially accounted for on the assumption that some substances in solution in the sap passed from the stalks to the pods.

METEOROLOGICAL CONDITIONS.

Date	Minimum Temperature	Maximum Temperature	Average Temperature of period	Rainfall (inches)
April 25—31	22	60	41.4	.42
May 1—31	25	76	51.1	1.37
June 1—10	30	76	54.8	.60
June 11—18	40	92	66.3	.....
June 19—25	39	84	65.1	.....
June 26—July 2	51	93	69.3	.....
July 3—9	56	92	72.2	.....
July 10—16	54	90	72.3	.52
July 17—23	48	93	74.2	.....
July 24—31	52	88	82.3	.08
Aug. 1—9	54	88	70.2	.66

TABLE IV.—RATE OF GROWTH.

(a) GREEN MATERIAL.

Date	Total	Leaves	Stalks	Flowers
June 19	+8002.	+5906.	+2096.	.....
" 26	+5086.	+3708.	+1378.	.....
July 3	+ 137.	—613.	+ 750.	.....
" 10	+15878.	+9089.	+4758.	+2031.
" 17	—7974.	—7363.	—3018.	+2406.
" 24	—4191.	—3482.	—2596.	+1888.
" 31	—7962.	—3494.	—1335.	—3133.

TABLE IV—RATE OF GROWTH—CONTINUED.

(b) DRY MATERIAL.

Date	Total	Leaves	Stalks	Flowers
June 19	+ 936.	+ 740.	+ 196.	.....
" 26	+ 692.	+ 507.	+ 185.	.....
July 3	+ 955.	+ 632.	+ 323.	.....
" 10	+2414.	+1468.	+ 687.	+ 259.
" 17	— 585.	— 847.	— 125.	+ 387.
" 24	— 916.	— 801.	— 577.	+ 462.
" 31	— 838.	— 612.	— 237.	+ 11.

(c) WATER.

Date	Total	Leaves	Stalks	Flowers
June 19	+7066.	+5166.	+1900.	.....
" 26	+4394.	+3201.	+1193.	.....
July 3	— 818.	—1245.	+ 427.	.....
" 10	+13464.	—7621.	+4071.	+1772.
" 17	—7389.	—6516.	—2893.	+2019.
" 24	—3275.	—2681.	—2020.	+1428.
" 31	—7124.	—2882.	—1097.	—3146.

THE PERCENTAGE COMPOSITION.

Table V below gives the percentage composition of the dry plant and its parts.

There is considerable difference in the composition of the leaves, stalks and flowers and pods. The most conspicuous differences are in the percentages of protein, albuminoids, crude fibre and fat. The per cent of crude fibre in the leaves is about the same as in the pods, but that in the stalks is about three times higher. The fat is highest in the leaves and lowest in the stalks, the per cent in the leaves being about three times that in the stalks. Both the albuminoids and the protein are highest in the pods and lowest in the stalks; but the amides—which are the difference between the albuminoids and the protein—do not differ much in the three parts, being slightly lowest in the stalks during the latter part of the

plant's life. The nitrogen-free extract is slightly higher in both the leaves and the pods than in the stalks. The per cent of ash is twice as high in the leaves as in the pods, while that in the stalks stands between the two.

The constant inconstancy of things is a noticeable fact in nature, and one that is markedly noticeable in the chemical composition of living things. Seeds of the same plant taken from the same bin and planted in different climates, or different soils, or different seasons, will produce plants having a somewhat different composition. The same plant at various stages of its growth has a different composition. Our knowledge of the chemical composition of a plant can, therefore, be only approximate.

This variation is much greater in some species of plants than in others. The composition of the pea vine, as shown in the table, is very constant during the growth of the plant, in comparison with many other plants. The variation in the whole plant is: Ash, 3.23%; crude fibre, 4.46%; crude fat, 0.8%; nitrogen-free extract, 6.77%; protein, 6.63%; abuminoids, 2.4%, and amides, 6.15%. The variation of protein and albuminoids in the leaves, and of crude fibre in the stalks and leaves, is a little greater, but otherwise it is not materially different in parts of the plant from the whole plant.

The composition of lucern as determined at this Station* varied in the whole plant as follows during its growth: Ash, 6.21%; crude fibre, 37.04%; crude fat, 3.18%; nitrogen-free exract, 10.46%; protein, 19.69%; albuminoids, 14.37%, and amides, 8.08%. It may be well to remember, in this comparison, that the growing period was much longer for the lucern than for the peas.

A comparison of the percentage composition of lucern and peas at the time of early bloom reveals a marked difference in the contents of crude fibre and protein of the two plants. The pea vine contains about 10% more protein and 12% less crude fibre than the lucern. The difference in the relative proportion of leaves and stalks in the two plants is as important a factor in this result as is the difference in composition of these organs.

* Bulletin 48.

TABLE V.—PERCENTAGE COMPOSITION. (DRY.)

(a) WHOLE PLANT.

DATE.	Ash	Crude Fibre	Crude Fat	Nitrogen-Free Extr't	Protein	Albuminoids	Amides
June 19	12.94	16.62	3.53	44.64	22.27	15.97	6.30
" 26	13.66	16.82	3.98	39.47	26.07	16.20	9.87
July 3	12.79	17.64	3.39	43.03	23.15	16.07	7.08
" 10	11.33	18.11	3.19	40.70	26.67	Not Determined.	
" 17	11.36	19.40	3.24	41.84	24.16	17.19	6.97
" 24	10.68	21.08	3.51	44.69	20.04	16.02	4.02
" 31	10.43	17.53	3.64	46.24	22.16	18.44	3.72

(b) LEAVES.

DATE.	Ash	Crude Fibre	Crude Fat	Nitrogen-Free Extr't	Protein	Albuminoids	Amides
June 19	13.32	11.93	4.12	45.95	24.68	18.45	6.23
" 26	14.17	11.56	4.73	39.71	29.83	19.00	10.83
July 3	13.10	10.89	4.09	45.36	26.56	19.38	7.18
" 10	12.25	10.75	4.02	41.46	31.52	20.95	10.57
" 17	12.90	11.26	4.35	43.57	27.92	20.00	7.92
" 24	14.07	16.09	4.67	46.84	18.33	13.15	5 18
" 31	14.46	15.07	5.01	46.28	19.18	14.33	4.85
Aug. 9	17.48	17.57	4.96	40.65	19.34	16.19	3.15

(c) STALKS

DATE.	Ash	Crude Fibre	Crude Fat	Nitrogen-Free Extr't	Protein	Albuminoids	Amides
June 19	11.50	34.34	1.28	39.71	13.17	6.60	6.57
" 26	12.01	34.00	1.52	38.70	13.77	7.07	6.70
July 3	11.97	35.67	1.50	36.81	14.05	7.24	6.81
" 10	9.70	37.21	1.34	38.96	12.79	6.69	6.10
" 17	10.01	37.84	1.42	40.19	10.54	6.64	3.90
" 24	9.33	42.70	1.19	41.52	5.26	4.06	1.20
" 31	11.33	38.19	1.18	41.86	7.44	5.61	1.83
Aug. 9	9.98	41.59	1.64	39.85	6.94	5.08	1.86

TABLE V—PERCENTAGE COMPOSITION. (DRY)—CONTINUED.

(d) FLOWERS AND PODS.

DATE.	Ash	Crude Fibre	Crude Fat	Nitrogen-Free Extr't	Protein	Albuminoids	Amides
June 19.....	.....	.....	....	.....	.....	. ...	....
" 26.....	.....	.....	....	.....	.....	.....	....
July 3.....	.....	.....	....	.....	.....	.....	....
" 10.....	8.11	10.84	2.54	40.15	38.36	Not Determined	
" 17.....	8.05	14.85	2.45	38.33	36.32	27.02	9.30
" 24.....	6.32	15.30	3.20	43.33	31.85	27.87	3.98
" 31.....	6.15	11.57	3.29	47.99	31.00	27.62	3.38
Aug. 9....	5.87	12.58	3.01	47.85	30.69	26.32	4.37

YIELD PER ACRE.

From the percentage composition and total yield of dry matter per acre can be calculated the yield of each of the ingredients. This has been done and the results exhibited below in Table VI.

It is noticeable that the greatest yield of each of the ingredients occurs in the same week—something which does not occur with all forage plants. The date of greatest yield in the present case was on July 10th, when the plants were in early bloom. The nitrogen-free extract was most abundant, being 2,033 lbs. The protein yield was 1,333 lbs.; crude fibre, 905; ash, 566; and fat, 159.

The date of greatest yield of all these ingredients was the same for the leaves and stalks as for the whole plant; but in the flowers the date of greatest yield was July 24th for the protein, ash and crude fibre, and July 31st for the fat, nitrogen-free extract and albuminoids.

Table VI shows very plainly the value of the leaves of the pea plant. Much the greater part of valuable food ingredients was contained in the leaves.

On July 10th they contained about 10-13 of the protein of the plant, about 13-20 of the nitrogen-free extract, and about 13-16 of the fat, while they contained very little more than one-third of the crude fibre which is of but little if any value as a food.

As the peas were just beginning to bloom at this time, very little of these materials was contained in the flowers, so the greater part of the remainder was contained in the stalks.

At other dates these proportions are different, and especially at later dates, as the pods increase from almost nothing up to 42% of the dry plant; but still this is the most important date for making the comparison.

The high yield of protein per acre and the low yield of crude fibre are very marked in the crop under consideration, at the the time of early bloom. This fact will be made clearer by a comparison with a crop of lucern in the same stage of growth, and which produced practically the same quantity of dry matter—4,881 lbs.—per acre as the crop we are considering.

The yield of crude fibre in the lucern crop was 1,475 lbs. per acre; that of the peas was 905 lbs.; the yield of protein in the lucern crop was 787 lbs., in the pea crop 1,333 lbs. The protein in the first crop of lucern, as above—787 lbs.—plus that in the second crop from the same field in the same season amouted to 1,306 lbs. Two crops of lucern thus produced less than one crop of peas, and the total amount—1,604 lbs.—from the three crops of lucern was not much greater than that from the one of peas.

The yield of nitrogen-free extract, ash and fat in the two crops did not differ very greatly. At later stages of growth the nitrogen-free extract and crude fibre were considerably increased in quantity in the lucern crop.

TABLE VI.—YIELD PER ACRE.

(a) WHOLE PLANT.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19	121.1	155.5	33.04	417.9	208.4	149.5	58.97
" 26	222.4	273.8	64.8	642.6	424.4	263.2	160.7
July 3	330.3	455.7	87.6	1111.5	597.9	415.1	182.9
" 10	566.2	905.0	159.4	2033.7	1332.7	.....	.....
" 17	501.2	855.9	142.9	1846.0	1066.0	758.5	307.5
" 24	373.4	737.0	122.7	1562.4	700.6	560.1	140.5
" 31	277.2	465.9	96.7	1229.1	589.0	490.2	98.88

TABLE VI—YIELD PER ACRE.—CONTINUED.

(b) LEAVES.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19..	98.6	88.3	30 50	340.00	182.6	136.5	46.11
" 26.....	176.7	144.2	59.00	495.2	372.0	236.9	135.1
July 3.....	246.2	204.6	76.85	852.4	499.1	364 2	134.9
" 10.....	410.0	359.6	134.60	1388.0	1055.0	701.2	353.8
" 17.....	322.5	281.5	108.80	1089.0	698.0	500.0	198.0
" 24.....	239.1	273.4	79.35	795.8	311.4	223.4	88 01
" 31.....	157.2	163.8	54.46	503.1	208.5	155.8	52.72

(c) STALKS.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19.....	22.54	67.3	2.5	77.83	25.8	12.94	12.88
" 26.....	45.76	129.5	5.79	147.4	52.46	26.94	25.53
July 3.....	84.27	251.1	10.56	259.2	98.91	50.97	47.95
" 10.....	134.9	517.6	18.64	541.9	177.9	93.06	84.84
" 17.....	126.7	479.1	17.98	508.8	133.4	84.07	49.37
" 24.....	64.29	293.2	8.20	286.1	36.24	27.98	8.2
" 31.....	51.21	172.6	5.33	189.2	33.63	25.36	8.2

(d) FLOWERS.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amids
June 19.....	.....	.....	.....	.....	.....	.....	... .
" 26.....	.....	.....	.....	.....	.....	... ..	.....
July 3	.....	.....	.....	.....	.....	.....	.....
" 10.....	21.01	28.08	6.58	104.0	99.35	.....	.....
" 17.....	52.01	95.93	15.83	247.6	234.6	174.6	60.08
" 24.....	70.03	169.5	35.45	480.1	352.9	308.8	44.1
" 31.....	68.82	129.5	36.82	537.0	346.9	309.1	37.82

RATE OF GROWTH.

In Table VII is shown the rate of growth of the various ingredients of the crop. The figures represent pounds per

acre which the crop gained or lost from the time of planting to June 19th and weekly thereafter, the sign — meaning loss.

The rapidity of growth of all the ingredients is a very conspicuous fact; but the quantity of protein produced in the week from July 3rd to July 10th is remarkable. 735 lbs. of protein in one week is only 52 lbs. less than a crop of lucern yielded during its entire growing period from early spring to June 22nd. The greatest quantity of carbohydrates (nitrogen-free extract), 922 lbs., produced in one week, is also about half as much as the same crop of lucern produced up to June 22nd.

It is in the leaves and pods where this remarkably rapid growth occurs principally. In the stalks the rate of growth is not materially different from that in the stalks of lucern, except in the case of crude fibre, which is produced more rapidly in those of the peas than in those of lucern.

TABLE VII.—RATE OF GROWTH.

(a) WHOLE PLANT.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19	121.1	155.5	33.04	417.9	208.4	149.5	58.97
" 26	101.3	118.3	31.76	224.7	216.0	113.7	101.73
July 3	107.9	181.9	22.80	468.9	173.5	151.9	22.2
" 10	235.9	449.3	71.8	922.2	734.8	.....	.....
" 17	—65.0	—49.1	—16.5	—187.7	—266.7	343.4	124.6
" 24	—127.8	—118.9	—20.2	—283.6	—365.4	—198.4	—167.0
" 31	—96.2	—271.1	—26.0	—333.3	—111.6	—69.9	—41.62

(b) LEAVES.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19	98.6	88.3	30.50	340.00	182.6	136.5	46.11
" 26	78.1	55.9	28.50	155.20	189.4	100.4	88.99
July 3	69.5	60.4	17.85	357.2	127.1	127.3	—0.2
" 10	163.8	155.2	58.75	535.6	555.9	337.0	218.9
" 17	—87.5	—78.3	—25.80	—299.0	—357.0	—201.2	—155.8
" 24	—83.4	—8.1	—29.45	—293.2	—386.6	—276.6	—109.99
" 31	—81.9	—9.6	—24.89	—292.7	—102.9	—67.6	—35.29

TABLE VII—RATE OF GROWTH—CONTINUED.

(c) STALKS.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19	22.54	67.3	2.50	77.83	25.80	12.94	12.88
" 26	23.22	62.2	3.29	69.57	26.66	14.00	12.65
July 3	38.51	121.6	4.77	111.80	46.45	24.03	22.42
" 10	50.63	266.5	8.08	282.70	78.99	42.09	36.89
" 17	—8.20	—38.5	—0.66	—33.10	—44.50	—8.99	—35.47
" 24	—62.41	—185.9	—9.78	—222.70	—97.16	—56.09	—13.12
" 31	—13.08	—120.6	—2.87	—96.90	—2.61	—2.62	—2.62

(d) FLOWERS.

Date	Ash	Crude Fibre	Crude Fat	Nitrogen-free Extract	Protein	Albuminoids	Amides
June 19	.....	.....	.....	.....	.....	.....	.....
" 26	.....	.....	.....	.....	.....	.....	.....
July 3	.....	.....	.....	....	.....	.....	.....
" 10	21.01	28.08	6.58	104.0	99.35	.....	.....
" 17	31.00	67.85	9.25	143.6	134.25	174.6	60.08
" 24	18.02	73.57	19.62	232.5	118.30	134.2	—15.98
" 31	—1 21	—40.00	1.37	56.9	—6.00	0.3	—6.28

FORAGE VALUE.

When this experiment was commenced it was hoped that some digestion trials would be made at this Station whereby data would be collected showing the digestibility of the various ingredients of pea vine hay. But up to the present none has been made. The work is somewhat incomplete without this data; and, in view of this fact, the digestibility of the protein was determined artificially by treatment with pepsin-hydrochloric acid. The results thus obtained taken in connection with data on the digestibility of similar hay, obtained from published records, will, doubtless, enable one to make a fairly accurate estimate of the forage value of the crop under consideration.

The treatment with pepsin-hydrochloric acid was carried out as follows: About two grams of the material being analyzed was placed in a beaker with 100 c c pepsin-hydrochloric acid, maintained at about 38° C for 8 hours, then allowed to stand at room temperature for 16 hours, after which it was again heated to 38° for three or four hours, filtered, washed, and nitrogen in the residue determined. The pepsin-hydrochloric acid solution was of the strength recommended in Wiley's *Principles and Practice of Agricultural Analysis;* viz, one gram pepsin in one liter of 0.33% hydrochloric acid.

This treatment is the same as that given to lucern in determining its digestibility (artificially) at this Station as recorded in Bulletin No. 58.

WHAT DETERMINES FORAGE VALUE.

There are several factors which enter into the determination of the forage value of a plant. In general, it may be said, though, that these are all included under the terms, yield per acre, composition, and digestibility. There is, to be sure, the practical question of cost of cultivation which, though very important in itself, can hardly be considered as having any direct bearing on the forage value.

The practicability of cultivation, the soil, the climate, etc., are factors which affect the yield and also to some extent the composition. But the kind of plant is the principal factor in determining composition.

In order to estimate the value of the factors, composition and digestibility, it is necessary to know the effects of the various ingredients of a plant upon the animal organism. At present we have a kind of general knowledge of these effects and can, therefore, make an approximate estimate of forage value; but there is yet much to be learned concerning the chemical physiology and composition of both animals and plants.

In general a food is said to have two purposes in the animal economy, one is to form the tissues of the body, the other is to supply the energy of the body. The three organic constituents of food—fat, carbohydrates, and protein—all supply energy, the fat supplying about 2¼ times as much energy, weight for weight, as the protein or carbohydrates. The protein is the only constituent from which that important tissue, the muscles, can be formed. The fat and carbohydrates are capable of being transformed into the fatty tissue of the body, which is merely the

storing up of energy for future use; and, while they can not form muscle, they have a conserving effect upon the consumption of protein.

The composition of a fodder will make it more valuable for some feeding purposes than for others; as, the proportion of nutrients required is different when feeding for the production of fat, or work, or milk, or for growth, or maintenance. The ratio of carbohydrates and fat to protein can be rather high when feeding for maintenance only; but when feeding for growth the ratio must be much lower.

EXPLANATION OF TERMS.

There are a few terms which are constantly met with in literature on stock feeding, which it may be well to explain briefly. *Nutrient* is a general term which includes the terms, protein, carbohydrates, fat and mineral matter or ash. The *coefficient of digestibility* is a number showing how many parts in one hundred parts of a nutrient are digestible. A *ration* is the weight of food eaten by an animal in a day. The *nutritive ratio* is the weight of digestible protein in a ration divided by the weight of digestible carbohydrates plus 2¼ times the weight of digestible fat. *Feeding standards* are tables showing the weight of food, the proportion of digestible nutrients and the nutritive ratio required per day by different animals when fed for various purposes as mentioned above.

HOW TO MIX A RATION.

It is evident that a single fodder can not answer all the purposes of an animal food, and that a mixed ration can be most economically used in many cases. A brief explanation of how rations are mixed is, therefore, inserted here.

To mix a ration it is necessary to know three things; first, the amount and proportion of digestible nutrients required for the special purpose in feeding; second, the composition of the foods to be fed; and third, the digestibility of the nutrients in the foods. In the past a great deal of experimental work has been done to determine these facts. The results have found expression in tables; the first, in tables of feeding standards; the second, in tables of composition; the third, in tables of digestibility.

A table of feeding standards, according to the German investigator, Wolff, is here inserted. It has been copied from Bulletin No. 163 of the North Carolina Experiment Station.

FEEDING STANDARDS.—ACCORDING TO WOLFF.

PER DAY AND PER 1,000 POUNDS LIVE WEIGHT.

	Total Organic Substance*	Nutritive (digestible) Substances			Total Nutritive Substance‡	Nutritive Ratio
		Protein	Carbo-hydrates†	Fats		
	Lbs.	Lbs.	Lbs	Lbs.	Lbs.	Lbs.
1. Oxen at rest in stall	17.5	0.7	8.0	0.15	8.85	1:12.0
2. Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	11.70	1:9.0
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	13.15	1:8.0
3. Oxen moderately worked	24.0	1.6	11.3	0.30	13.20	1:7.5
Oxen heavily worked	26.0	2.4	13.2	0.50	16.10	1:6.0
4. Horses lightly worked	20.0	1.5	9.5	0.40	11.40	1:7.0
Horses moderately worked	22.5	1.8	11.2	0.60	13.60	1:7.0
Horses heavily worked	25.5	2.8	13.4	0.80	16.20	1:6.0
5. Milk cows	24.0	2.5	12.5	0.40	15.40	1:5.4
6. Fattening oxen, 1st period	27.0	2.5	15.0	0.50	18.00	1:6.5
Fattening oxen, 2d period	26.0	3.0	14.8	0.70	18.50	1:5.5
Fattening oxen, 3rd period	25.0	2.7	14.8	0.60	18.10	1:6.0
7. Fattening sheep, 1st period	26.0	3.0	15.2	0.50	18.70	1:5.5
Fattening sheep, 2d period	25.0	3.5	14.4	0.60	18.50	1:4.5
8. Fattening swine, 1st period	36.0	5.0	27.5		32.50	1:5.5
Fattening swine, 2d period	31.0	4.0	24.0		28.00	1:6.0
Fattening swine, 3rd period	23.5	2.7	17.5		20.20	1:6.5
9. Growing cattle:						
Age. Mos. — Average live weight per head.						
2—3 — 150 lbs	22.0	4.0	13.8	2.0	19 8	1:4.7
3—6 — 300 lbs	23.4	3.2	13.5	1.0	17.7	1:5.0
6—12 — 500 lbs	24.0	2.5	13.5	0.6	16.6	1:6.0
12—18 — 700 lbs	24.0	2.0	13.0	0.4	15.4	1:7.0
18—24 — 850 lbs	24.0	1.6	12.0	0.3	13.9	1:8.0
10. Growing sheep						
5—6 — 56 lbs	28.0	3.2	15.6	0.8	19.6	1:5.5
6—8 — 67 lbs	25.0	2.7	13.3	0.6	16.6	1:5.5
8—11 — 75 lbs	23.0	2.1	11.4	0.5	14.0	1.6.0
11—15 — 82 lbs	22.5	1.7	10.9	0.4	13.0	1:7.0
15—20 — 85 lbs	22.0	1.4	10.4	0.3	12.1	1:8.0

FEEDING STANDARDS.—ACCORDING TO WOLFF.—CONTINUED.

PER DAY AND PER 1,000 POUNDS LIVE WEIGHT.

		Total Organic Substance*	Nutritive (digestible) Substances			Total Nutritive Substances‡	Nutritive Ratio
			Protein	Carbo-hydrates†	Fats.		
11. Growing fat pigs		Lbs.	Lbs.	Lbs.		Lbs.	Lbs.
2—3	50 lbs.....	42.0	7.5	30.0		37.5	1:4.0
3—5	100 lbs.....	34.0	5.0	25.0		30.0	1:5.0
5—6	125 lbs.....	31.5	4.3	23.7		28.0	1:5.5
6—8	170 lbs.....	27.0	3.4	20.4		23.8	1:6.0
8—12	250 lbs	21.0	2.5	16.2		18.7	1:6.5

NOTE.—The feeding periods mentioned in the above table have reference to the divisions of the whole time an animal is fed, and their respective lengths will depend on how long the animal is to be fed, its conditions at beginning, and the judgment of the feeder.

*Represents the water free food (or dry matter), less ash.

†Nitrogen-free extract and crude fibre are taken together to form carbohydrates.

‡Sum of the three preceding columns.

NOTE.—The above figures represent German pounds, which are 1.1 times the avoirdupois. In practice, though, it will hardly be necessary to take cognizance of this fact.

An example will show how to use these facts in compounding a ration. Suppose it is for a milch cow that we wish a ration mixed. From the table of feeding standards given above we learn that for this purpose digestible nutrients are required as follows, per day, for an animal weighing 1000 pounds: Protein, 2.5 lbs.; carbo-hydrates, 12.5 lbs.; and fat, 0.40 lbs. If we have pea vine hay, oat hay and beet pulp we may get a suitable ration. From table V, pea vine hay is seen to contain 18.11% crude fibre; 40.70% nitrogen-free extract; 26.67% protein, and 3.19% fat. These numbers, multiplied by the co-efficients of digestibility will give the amount of digestible nutrients in 100 pounds of the hay. Table VIII shows the co-efficient for protein to be about 77; that for fat may be assumed to be about 50, which is nearly the co-efficient for the fat of lucern. It has been found that the amount of digestible carbo-hydrates (nitrogen-free extract plus crude fibre) in one hundred parts of hay is nearly equal to the percent of nitrogen-free extract. The results of these operations show the digestible nutrients in one hundred pounds of pea vine hay to be:

Carbohydrates, 41 lbs.; protein, 20 lbs.; and fat, 1.6 lbs. In one pound of hay there will, therefore, be 0.41 lb. carbohydrates, 0.20 lb. protein, and 0.016 lb. fat. By similar operations we find the digestible nutrients in one pound oat hay to be: Carbohydrates, 0.50 lb.; protein, .05 lb.; and fat, 0.0128 lb. All the ingredients in the beet pulp are assumed to be digestible, and one pound contains: Carbohydrates, 0.047 lb.; protein, 0.008 lb.; and fat, 0.0013 lb.

After learning the amounts of digestible nutrients in one pound of each of the foods at hand, it remains to determine the proportions in which the foods must be mixed in order that the nutrients in the food will agree with those in the standard. This can only be done by making trial computations with various amounts of the foods until the right proportion is obtained. If a computation be made with 11 pounds of pea vine hay, 14 pounds of oat hay and 20 pounds of beet pulp, the sum of the carbohydrates in the three foods will be found to be 12.45 lbs., which is near enough the standard; but these proportions of hay contain 3.06 lbs. of protein, which is above that required by the standard. Evidently we must use less of the hay rich in protein and more of that rich in carbohydrates. Eight pounds pea vine hay, 16 pounds oat hay and 20 pounds of beet pulp, will contain 12.22 lbs. of carbohydrates, 2.56 lbs of protein and 0.35 lb. of fat, which agree closely enough with the ration required.

This ration is for an animal weighing 1000 pounds. If the animal to be fed weighs 700 pounds, 7-10 of the ration should be taken, and corresponding proportions for animals of different weight.

Some of the above computations are only approximately correct. In practice absolute accuracy in compounding rations is impossible on account of the varying composition and digestibility. Feeding standards and tables of composition and digestibility furnish guides for the exercise of judgment, not rules to be blindly followed.

DIGESTION WITH PEPSIN-HYDROCHLORIC ACID.

Table VIII has been compiled from the results of the artificial digestion. The leaves, stalks and flowers were digested separately, and from the results the data for the

whole plant computed. On account of the samples of flowers for July 10th and 17th being exhausted, the digestibility of the whole plant on these dates could not be computed exactly, but it is, doubtless, between the digestibility of the stalks and that of the leaves. I have estimated the weight of digestible protein and albuminoids per acre to be 993 and 525 pounds, respectively, on July 10th. This makes the digestion co-efficient for protein a little less than 75, which is very likely too low.

An inspection of the table shows that the digestibility of the albuminoids is nearly the same in the whole plant, the leaves, and the stalks. At early bloom the co-efficient is about 62. The greatest variation is about 4.8% for the whole plant, 5.7% for the leaves, 12.7% for the stalks and 19.86% for the flowers and pods.

The total protein is, of course, more digestible than the albuminoids, and the variation is also greater. In the whole plant the variation is about 7% or 8%; in the leaves, about 10.9%; in the stalks, 19.2%, and in the flowers and pods 19.2%.

The digestibility of the protein in the whole plant, leaves and stalks increases until early bloom, then decreases. The same is true of the albuminoids in the leaves and stalks but not in the whole plant, in the flowers the digestibility of both protein and albuminoids increases to maturity of the seed.

While the leaves and stalks were increasing in dry weight, up to early bloom, the protein in the latter was more digestible than that in the former. On July 24th and 31st the protein of the stalks was a little less digestible than that of the leaves. The per cent of protein in the leaves is more than twice that in the stalks; the per cent of crude fibre in the stalks is about three times that in the leaves. On July 24th and 31st the per cent of protein in the flowers and pods was nearly three times that in the stalks. The digestibility of the protein in the pods at this time was considerably lower than that of the protein in the stalks when they were growing. It has been similarly noticed at this Station that, by artificial digestion, the protein of the stalks of lucern is more digestible than that of the leaves in the earlier life of the plant; yet the stalks contain a lower per cent of protein and a higher per cent of crude fibre. These facts are hardly in accord with the belief that the higher the per cent of protein and the lower the per cent of crude fibre in a fodder the greater is the digestibility of the protein.

The digestibility of the albuminoids in the leaves, stalks and flowers also point to this conclusion, showing that the influence of the amides does not vitiate it.

The per cent of nitrogen-free extract in the leaves is a little higher than in the stalks, while the digestibility of the albuminoids is practically the same in both. In the flowers on July 24th the albuminoid co-efficient of digestion was 59.0, on August 9th it was 78.9; yet, on the latter date, the nitrogen-free extract was 4.5 per cent higher than on the former. This indicates that the increased percentage of carbohydrates in the pea vine has no depressing effect upon the digestibility of its protein.

In comparing the yield of digestible nutrients per acre in the pea vine crop with the yield from the lucern crop used in previous comparisons, we find that for the fat and carbohydrates the difference is very slightly in favor of the pea vine hay. This statement is made on the assumptions that the fat of the pea vine is not very much less digestible than that of lucern and that the percentage of nitrogen-free extract in the pea vine hay is equal to the percentage of digestible carbohydrates. The lucern crop yielded 551 pounds of digestible protein per acre, while the crop of peas yielded 993 pounds. The difference is 442 pounds in favor of the pea vine hay. This is sufficient to supply the protein in a ration of a milk cow for six months.

TABLE VIII.—ARTIFICIAL DIGESTION WITH PEPSIN-HYDROCHLORIC ACID

WHOLE PLANT.

DATE.	Per cent Protein Digested	Per cent Protien Undigested	Co-efficient of Digestibility Protein	Co-efficient of Digestibility Albuminoids	Weight of Digestible Protein per Acre in lbs.	Weight of Digestible Albuminoids Per Acre in lbs.
June 19...	15.61	6.66	70.09	58.30	146.1	87.2
June 26...	19.29	6.78	73.99	58.15	314.0	153.1
July 3...	16.17	6.98	69.85	56.57	417.7	234.8
July 10...	?	?	?	?	993.0	525.0
July 17...	?	?	?	?	?	?
July 24...	13.67	6.37	68.21	60.23	477.9	337.3
July 31...	15.88	6.28	71.66	63.07	422 1	323.2

TABLE VIII—ARTIFICIAL DIGESTION WITH PEPSIN-HYDROCHLORIC ACID—CONTINUED.

LEAVES.						
June 19...	16.97	7.71	68.76	58.21	125.6	79.5
June 26...	21 87	7.96	73.32	58.11	272.8	137.7
July 3...	18.14	8.42	68.30	56.55	340.8	206.0
July 10...	23.94	7.57	75.95	63.82	801.3	447.5
July 17...	20.24	7.68	72.49	61.60	506.0	308.0
July 24...	13.51	4.82	73.70	63.35	229.5	141.5
July 31...	13.57	5.61	70.75	60.85	147.5	94.8
Aug. 9...	12.58	6.76	65.05	58.25	?	?
STALKS.						
June 19...	10.49	2.68	79.65	59.39	20.6	7.7
June 26...	10.87	2.90	78.94	58.98	41.4	15.9
July 3...	11.27	2.78	80.20	61.60	79.3	31.4
July 10...	10.26	2.53	80.22	62.18	142.7	57.9
July 17...	7.93	2.61	75.24	60.69	100.4	51.0
July 24...	3.21	2.05	61.03	49.51	22.12	13.9
July 31...	4.76	2.68	63.98	52.23	21.52	13.3
Aug. 9...	4.66	2.28	67.15	55.12	?	?
FLOWERS.						
July 24...	20.43	11.42	62.68	59.02	226.4	182.3
July 31...	22.61	8.39	72.94	69.62	253.0	215.2
Aug. 9...	25.13	5.56	81.88	78.88	?	?

Two years ago the writer, while working under the direction of Prof. Widtsoe, made some analyses of lucern, wheat and oats, which showed that the per cent of protein insoluble in pepsin hydrochloric acid was practically a constant quantity in the leaves and stalks of these plants. But the constant in the leaves was not the same as that in the stalks, nor did the same organ of all three plants have the same constant. These analyses were discussed in Bulletin No. 58 under the title, "*The Constancy of the Nuclein.*"

In making this study of the digestibility of the protein of pea vine hay, a similar constancy is noticeable in the residue of leaves and stalks from the treatment with pepsin-hydrochloric acid. This is shown in table VIII, in the column giving the per cent of protein undigested. The constancy is very marked

in the stalks, and also in the leaves with two exceptions on July 24th and 31st, which may be due to accident. In the flowers and pods there is no constancy; but this may be due to the fact that the flowers, pods and contents were all mixed together for analysis.

PERCENTAGE NUCLEIN IN LEAVES AND STALKS OF PLANTS.

When Grown	Kind of Plant.	Leaves	Stalks
1896	Lucern; first crop; 14 analyses, May 4th to August 24th	7.37	3.50
1897	Lucern; second crop; young	6.78	2.93
1897	Lucern; first crop; old	6.88	2.32
1899	Peas; average of analyses in table VIII omitting those of leaves on July 24th and 31st	7.68	2.56
1897	Wheat; very young	4.04	1.55
1897	Wheat; ripe	3.90	?
1897	Oats; very young	3.48	1.58
1897	Oats; ripe	3.46	1.29

The above analyses, except those of the peas, have been obtained from Bulletin No. 58 of this Station. An inspection of the table shows that the two leguminous plants, peas and lucern, do not differ greatly from each other in the per cent of nuclein which their organs contain. The same thing may be said of the two graminaceous plants, wheat and oats. But quite a marked difference is noticeable, especially in the leaves, between the two families.

TIME TO CUT PEAS FOR HAY.

On account of the comparative constancy in composition, there is not much choice as far as this factor is concerned in the time to cut; but what little difference there is, is in favor of cutting in early bloom, the percentage of protein being highest at this time.

The digestibility of the protein is also greatest on July 10th, in early bloom; but the percentage of nitrogen-free extract is greatest on July 31st; and, consequently, according to the assumption made above, the digestibility of the carbohydrates would be greatest at this time. We have no data as to the digestibility of the fat, but this is of slight importance.

The total yield of dry matter was greatest on July 10th. Taking into consideration now all these factors, we find that the total yield of digestible protein was very much greater in early bloom than at either an earlier or latter period. Table VI shows the yield of nitrogen-free extract (equal to digestible carbohydrates) to be very materially greater in early bloom than at any other time. The facts all point strongly to early bloom as being the most suitable time to cut pea vines for hay.

This conclusion is not in accordance with the practice, which is to cut when the peas are nearly ripe. Mr. J. G. Smith of the Division of Agrostology states* that the time to cut peas for forage is when the dominant variety in the mixture is nearly ripe.

On account of their high per cent of protein the peas themselves are much more valuable, weight for weight, than the vines; but notwithstanding this fact the crop used in this experiment showed a loss of digestible protein from early bloom to maturity, amounting to 571 pounds per acre.

The extremely rapid growth of this crop and the somewhat rapid loss in dry weight after reaching the maximum, show the importance of cutting at the proper time. A few days seem to make a considerable difference. Whether the best time will always be within one week after the first flowers appear, can be determined only by further investigation.

OTHER CONSIDERATIONS.

The high content of protein in the pea vine makes it imperative that this fodder should be mixed with some other food richer in carbohydrates. The nutritive ratio in early bloom was narrower than the ratio 1:2. For young growing animals, which require the greatest amount of protein, the nutritive ratio ought not to be narrower than about 1:4 or 5. Feeding the pea vine hay alone would, consequently, cause a waste of the most valuable nutrient, protein.

Timothy, redtop, straw, or hay made from the cereals would, perhaps, be suitable fodders to mix with the pea vines. Root crops such as mangels, beets, carrots, etc., would also be

*Yearbook 1897.

valuable admixtures. A ration like the one used as an illustration on a previous page; viz., pea vine hay, oat hay and beet pulp, would very likely give good results.

As a soiling crop peas have given excellent results. As a pasture for growing and fattening pigs, a patch of peas is very useful. The flesh of pigs, fattened in this way, is said to produce excellent pork.

ACKNOWLEDGMENTS.

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SUMMARY.

In the different organs, when growing, the per cent of water is above 80.

The stalks contain a higher per cent of water than the leaves.

The pea vine is more succulent than lucern.

The per cent of leaves is higher in the dry than in the green plant.

At early bloom, the dry plant is two-thirds leaves, and about one-fourth stalks.

The highest per cent of leaves occurs in the early life of the plant; of stalks, in early bloom; of pods, at maturity.

The yield of dry matter is equal to that of a crop of lucern.

The greatest yield occurs in early bloom, after which there is a very material loss of dry matter.

The pea vine is an extremely rapid grower.

Relatively, the leaves grow most rapidly first, then the stalks, then the pods.

During its growth the composition of the pea vine is comparatively constant.

The per cent of protein is high.

The per cent of crude fibre is low.

The per cent of crude fibre is about three times greater in the stalks than in the leaves.

The per cent of fat is about three times greater in the leaves than in the stalks.

The per cent of protein is about three times greater in the flowers and pods, and about two times greater in the leaves than in the stalks.

The per cent of albuminoids is about four times greater in the flowers and pods, and about three times greater in the leaves than in the stalks.

The greatest yield of each nutrient occurred in early bloom.

The acre yield of protein was 546 pounds more, and of crude fibre 570 pounds less than that of a crop of lucern in early bloom.

The protein appears to be slightly more digestible than that of lucern.

It is most digestible in early bloom.

It is more digestible in the stalks than in the leaves.

In the flowers a great increase in digestibility of protein occurred simultaneously with an increase in per cent of nitrogen-free extract.

Pound for pound pea vine hay appears to be more valuable than lucern hay.

The facts point to early bloom as being the most suitable time to cure for hay.

The loss of nutrients, especially protein, after early bloom is very conspicuous.